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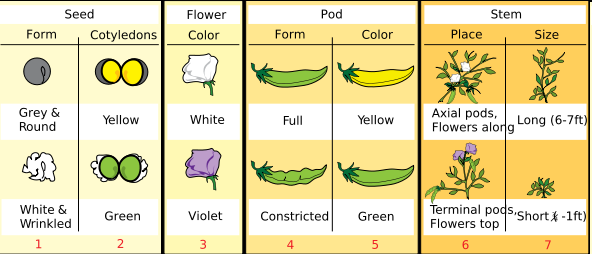
**Unit 7, Part 1 Notes: Mendel and Basic Crosses**

Pre-AP Biology, Mrs. Krouse

1. ***Genetics*** is the study of how traits are passed down from parents to offspring. We can also define genetics as the study of heredity. ***Heredity*** is defined as the passing of traits from parents to offspring.

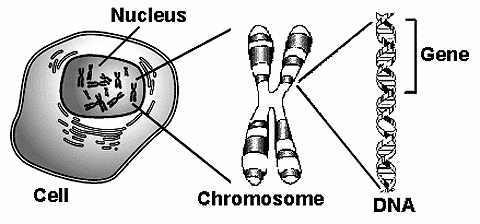


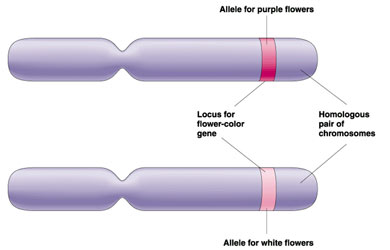
1. The scientist who conducted some of the first well-known studies in the field of genetics was an Austrian monk named Gregor Mendel. He is known as the “father of modern genetics.” He studied the inheritance of traits in garden pea plants. Some examples of traits that he studied were flower color, seed shape, stem length, etc.



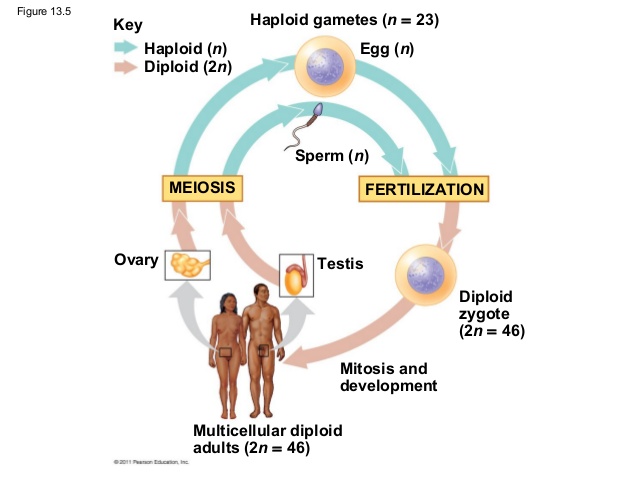
1. For a little background on Mendel, he lived from 1822-1884, but his work was not widely recognized until the early 1900s. From 1856-1863, Mendel grew and tested 28,000 pea plants.

1. During his research, Mendel noticed that certain physical traits seemed to be passed from parent plants to offspring (baby) plants. He stated that these traits were inherited as “particles.” We now know that these so-called “particles” are actually ***chromosomes***, which do get passed down from parents to offspring. Remember, you received 23 of your 46 chromosomes from your mother and 23 from your father.



1. We also now know that there are short sections of chromosomes called ***genes*** that code for particular traits. Each person has two genes for a particular trait. One gene came from the person’s father, and one gene came from the person’s mother. They sit on chromosomes that form a ***homologous pair***. Remember when we learned about pairs of homologous chromosomes in Unit 6 (Cell Division)? These are pairs of chromosomes that have the same types of genes in the same places.
2. We call the area of a chromosome where a particular gene is located that gene’s “***locus***.”
3. There can be different forms or types of a particular gene. These different gene forms are called ***alleles***. For example, if we are talking about Mendel’s pea plants, and the trait is flower color, there are two alleles for flower color—a purple allele and a white allele.
4. We call the combination of two alleles that a person has for a particular trait his/her ***genotype***. The genotype determines the ***phenotype***, which is the physical trait that is shown (ex: flower color). The image to the right shows a pair of homologous chromosomes from a garden pea plant. The chromosomes are un-replicated because the plant cell is still in the G1 stage, which is why they do not look like X’s. Notice that the alleles for the flower color gene are found at the same location (i.e., locus) on each chromosome. One chromosome contains a purple flower allele, and the other chromosome contains a white flower allele.
5. Typically one allele form will “cover up” or “mask” the expression of the other allele. We call this allele the ***dominant allele***, and we use a capital letter to represent this allele. For example, the purple flower allele is dominant, so we will use a capital “A” to represent this allele.
6. When present, the dominant allele determines the physical trait (phenotype) that is shown. For example, if a pea plant has at least one purple flower allele (A), it will show the purple flower phenotype. In other words, it will have purple flowers.
7. We call the other allele (the one that is covered up or masked) the ***recessive allele***, and we use a lowercase letter to represent this allele. For example, the white flower allele is recessive, so we will use a lowercase “a” to represent this allele. There must be two copies of this allele for the recessive phenotype to be shown. For example, if a pea plant has two copies of the white flower allele (a), it will show the white flower phenotype. In other words, it will have white flowers.
8. When an individual has two copies of same allele (ex: AA or aa), we call that organism’s genotype ***homozygous***. There are two types of homozygous genotype. When there are two dominant alleles (ex: AA), we call that organism’s genotype ***homozygous dominant***. When there are two recessive alleles (ex: aa), we call that organism’s genotype ***homozygous recessive***.
9. When there is one copy of the dominant allele and one copy of the recessive allele (ex: Aa), we call that organism’s genotype ***heterozygous***.
10. Let’s say there are two alleles for eye color, brown (B) and blue (b). The possible genotypes and their corresponding phenotypes are given below:

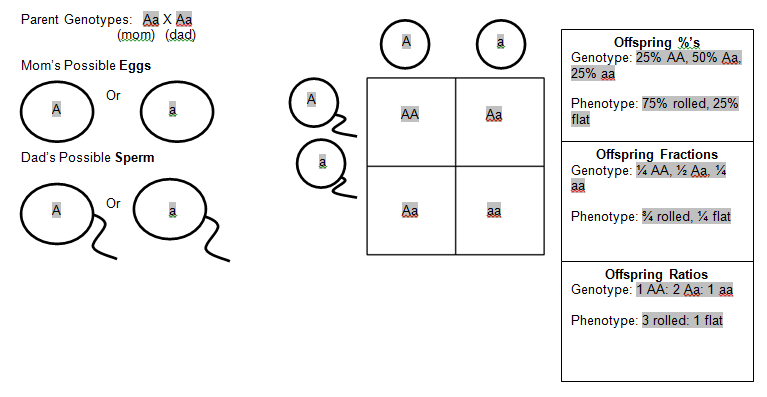
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| **Genotype Letters** | **Genotype Descriptions** | **Phenotypes** |
| BB | Homozygous Dominant | Dominant (Brown Eyes) |
| Bb | Heterozygous | Dominant (Brown Eyes) |
| Bb | Homozygous Recessive | Recessive (Blue Eyes) |



1. Because pairs of homologous chromosomes must divide during ***meiosis*** to create eggs and sperm (i.e., ***gametes***) with half the chromosomes found in a normal body cell, each gamete only receives one allele for a particular trait. Therefore, when ***fertilization*** of the egg by the sperm occurs, the fertilized egg (***zygote***) will receive one allele from each parent. This zygote can then divide many times by ***mitosis*** to create a multicellular baby with two alleles for each trait.
2. We can use a tool called a Punnett square to predict the possible ***genotypes for offspring*** based on possible allele combinations created by the two ***parental gametes***. See the example given below…

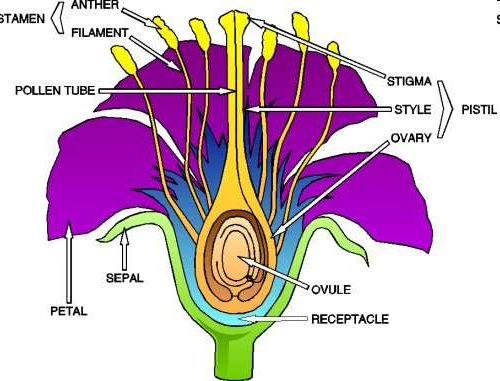
*Note, the axes or sides of the boxes show the alleles found in the gametes from each parent (dad on the left, mom on top). Normally, we do not actually show the eggs and sperm, but I have shown them here for clarification. The inner four boxes show the possible genotypes for offspring (children) from these two parents. Answers are shaded in gray for this example.*

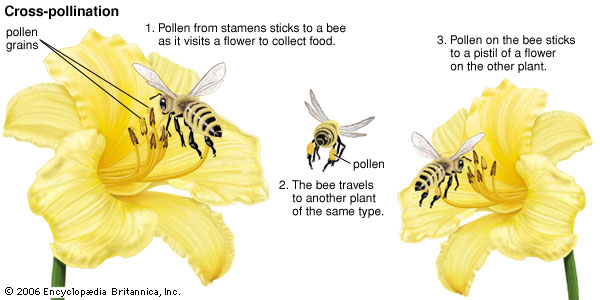
In humans, the ability to roll the tongue is dominant. “***A***” represents the rolled tongue allele, and “***a***” represents the flat tongue allele. Show a cross between a mom and dad that are both ***heterozygous*** for tongue rolling and find your offspring genotypes and phenotypes in ***percentages, fractions, and ratios.***



1. In Gregor Mendel’s famous genetics experiments with pea plants, he conducted genetic “***crosses***” (breedings) with plants that were ***purebred*** for a trait (homozygous). He called these plants the “***P***” or parent generation. Let’s say one parent is homozygous dominant for purple flowers (PP) and the other parent is homozygous recessive for white flowers (pp).
2. When Mendel bred the plants of the parent generation (PP x pp), all the offspring were hybrids (heterozygous). In our example, all the offspring would be heterozygous for purple flowers (Pp). This generation is called the ***F1*** (first filial) generation. The Punnett square that represents this cross is given below. I have ***bolded and italicized*** the uppercase ***P*** so that the difference between the uppercase and lowercase p is more clear.

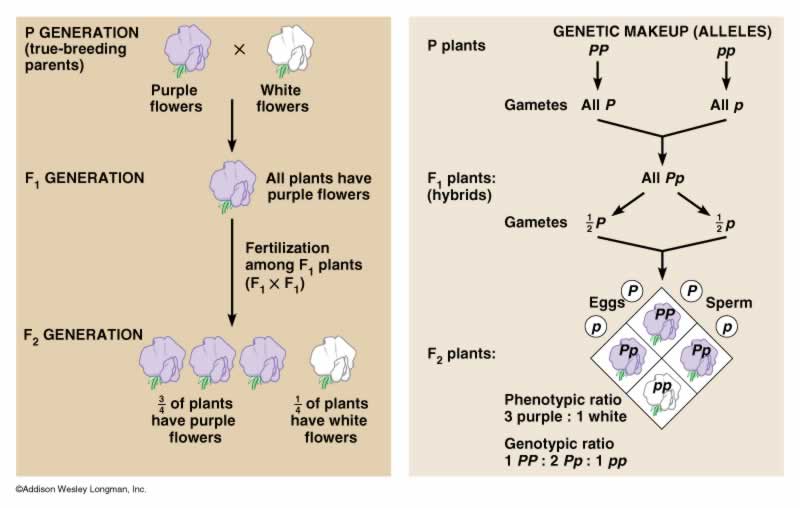
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| **Parent Genotypes:** ***PP*** x pp | |  |  |  | | --- | --- | --- | |  | ***P*** | ***P*** | | p | ***P***p | ***P***p | | p | ***P***p | ***P***p | | **Offspring %’s:**  Genotype: 100% ***P***p  Phenotype: 100% Purple  **Offspring Fractions**  Genotype: 4/4 ***P***p  Phenotype: 4/4 ***P***p  *Note: I have not shown offspring* ***ratios*** *for this problem.* |

Note: When Mendel bred the parent generation plants, he took ***pollen*** (the male gamete) from one plant. He collected this pollen from the ***stamen***, which is the male reproductive part of the flower. The stamen contains the ***anther***, which is where the pollen grains are located, and the ***filament***. The filament is a long stalk on which the anther sits. Once Mendel collected pollen from a flower on one plant, he then placed it on the ***stigma*** of a flower on another plant. The pollen traveled from the stigma through a tube-like structure called the ***style*** to a chamber called the ***ovary***. In the ovary, the pollen fertilized the egg. The zygote and later embryo that resulted from this fertilization forms a seed that can grow into a baby plant of the F1 generation. Together, the stigma, style, and ovary make up the ***pistil***, which is the female reproductive structure of the flower. When pollen is transferred between flowers of two separate plants, this is called ***cross-pollination***. Mendel did this himself, but it happens in nature when pollen is spread by wind or by “pollinators.” Pollinators are birds or insects that are attracted to nectar produced by the flower and happen to get pollen stuck on their bodies. When they visit the next plant, some of this pollen may brush off onto another flower.



1. Mendel then allowed the plants of the F1 generation to ***self-pollinate***. This means that pollen was transferred from the anthers to the stigma of the same flower or another flower on the same plant. The offspring that resulted from this cross were called the ***F2*** (second filial) generation. As such, the parent genotypes for this cross are ***P***p and ***P***p (the same). The results of this cross are shown below.

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| **Parent Genotypes:** ***P***p x ***P***p | |  |  |  | | --- | --- | --- | |  | ***P*** | p | | ***P*** | ***PP*** | ***P***p | | p | ***P***p | pp | | **Offspring %’s:**  Genotype: 25% ***PP***, 50% ***P***p, 25% pp  Phenotype: 75% Purple, 25% White  **Offspring Fractions:**  Genotype: 1/4 ***PP***, 1/2 ***P***p, 1/4 pp  Phenotype: 3/4 Purple, 1/4 White  **Offspring Ratios:**  Genotypes: 1 ***PP*** : 2 ***P***p : 1 pp  Phenotypes: 3 Purple : 1 White |

1. Mendel noticed that the white flower trait did not show up in the F1 generation but showed up again in the F2 generation. He concluded that the white flower allele was a recessive allele that was “carried” by the purple plants in the F1 generation (genotype Pp). This led him to his first law of inheritance, which is called the ***Law of Dominance.*** Essentially, this law describes the difference between dominant and recessive alleles. The Law of Dominance is one of three laws of inheritance described by Mendel. We will learn about these ***laws of inheritance*** as a class at the end of this notes packet.
2. A summary of Mendel’s basic experiments on the flower color trait is given in the image below.
3. Some examples of genetic crosses that are analyzed with Punnett squares are given below. These are all monohybrid cross, which means they track the inheritance of one trait (ex: flower color) from parents to offspring. In our next notes packet, we will learn about dihybrid crosses, which track the inheritance of two traits (ex: flower color and plant height) from parents to offspring.
4. When solving a Punnett square problem, you should follow the steps given below.
5. Highlight or underline information in the question about the following things…
6. Which allele is dominant, and which allele is recessive.
7. What the parent phenotypes or genotypes are.
8. Write out the parent genotypes (ex: Aa x AA).
9. Write possible gametes for each parent on the top and left sides of the square (ex: A and a on top; A and A on the left). I always put the first parent’s gametes on the top of the square, and the second parent’s gametes on the left side of the square, but you can do it either way and still get the same results.
10. Fill in the boxes of the square with the potential offspring genotypes. If one of the potential offspring genotype is heterozygous (ex: Aa), always write the dominant allele (ex: A) before the recessive allele (ex: a).
11. Determine the offspring genotype and phenotype frequencies. I may ask you to write these frequencies as percentages, fractions, or ratios, so you need to be comfortable doing all of them! For my examples given below, I have used percentages only.

**Sample Problem #1:** In pea plants, the allele for green pea pods (G) is dominant. The allele for yellow pea pods (g) is recessive. Show a cross between a homozygous green-podded plant and a yellow-podded plant.

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| **Parent Genotypes:** GG x gg | |  |  |  | | --- | --- | --- | |  | G | G | | g | Gg | Gg | | g | Gg | Gg | | **Offspring %’s:**  Genotype: 100% Gg  Phenotype: 100% green pods |

**Sample Problem #2:** Show a cross between a homozygous green-podded plant and a plant that is heterozygous for pod color.

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| **Parent Genotypes:** GG x Gg | |  |  |  | | --- | --- | --- | |  | G | G | | G | GG | GG | | g | Gg | Gg | | **Offspring %’s:**  Genotype: 50% GG, 50% Gg  Phenotype: 100% green pods |

**Sample Problem #3:** Show a cross between two plants that are heterozygous for pod color.

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| **Parent Genotypes:** Gg x Gg | |  |  |  | | --- | --- | --- | |  | G | g | | G | GG | Gg | | g | Gg | gg | | **Offspring %’s:**  Genotype: 25% GG, 50% Gg, 25% gg  Phenotype: 75% green pods, 25% yellow pods |

**Sample Problem #4:** Show a cross between a plant that is heterozygous for green pods and a plant that has yellow pods.

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| **Parent Genotypes:** Gg x gg | |  |  |  | | --- | --- | --- | |  | G | g | | g | Gg | gg | | g | Gg | gg | | **Offspring %’s:**  Genotype: 50% Gg, 50% gg  Phenotype: 50% green pods, 50% yellow pods |

**Sample Problem #5:** Show a cross between two plants that have yellow pods.

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| **Parent Genotypes:** gg x gg | |  |  |  | | --- | --- | --- | |  | g | g | | g | gg | gg | | g | gg | gg | | **Offspring %’s:**  Genotype: 100% gg  Phenotype: 50% green pods, 50% yellow pods |

***IMPORTANT: The notes below about Mendel’s Laws of Inheritance will be completed as a class.***

1. Describe Mendel’s ***Law of Dominance*** in the space below and draw a picture in the box to the right.
2. Describe Mendel’s ***Law of Segregation*** in the space below and draw a picture in the box to the right.
3. Describe Mendel’s ***Law of Independent Assortment*** in the space below and draw a picture in the box to the right.